Meade Autostar Image Processing

For Windows™

Version 3.12
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Introduction *7*
A Note on Accuracy **7**
System Requirements **7**
Registering the Program **7**
1. Installation *8*
2. Features *9*
Tool Bar *9*
3. File *10*
Open **10**
8 Bit versus 12 or 16 Bit or Floating Point Grayscale Images 11
Close **12**
Save As Fits Image **13**
Export Display As **13**
Print **13**
Printer Setup **13**
Page Setup **14**
Exit **14**
4.View *15*
Zoom Image Size **15**
Scale **15**
Palettes **17**
Contour **18**
Error! Objects cannot be created from editing field codes. **18**
Blink **18**
5.Tools *19*
Coordinates **19**
Histogram **19**
Magnifier **19**
Information **20**
6.Process *21*
Undo **21**
Calibrate **21**
Merge **21**
Correct Column Defect **21**

Flip Image 21
Rotate Image 21
Resample 22
Convolution Filters 22
Unsharp masking 23
Median Filter 23
Fix Hot Pixels 23
Fix Cold Pixels 23
Add Noise 24
Stretch Image 24
RGB Merge 25
7. Image Utilities *27*
Set Reference Magnitude 28
Image Statistics 30
Draw Profile 30
List Pixel Values 31
Edit Log File 32
8. Group Operations *33*
Group Edit 33
Copy 34
Examine 34
Delete 34
Calibrate 34
Align 34
Combine 35
Filter 35
Normalize 35
Fix Column Defect 35
Photometry 35
9. Options *37*
Night Vision 37
Preferences 37
Grayscale Palette and Standard Palette 38
Appendix A *39*

Image Processing Basics **39**
Bibliography ***41***
Glossary ***42***

Introduction

Welcome to Meade Autostar IP astronomical image processing software. Now you can perform many of the same image processing tasks that a professional astronomer would do on a large institutional computer. With Meade Autostar IP you can:

- Enhance high resolution images using advanced image processing techniques.
- Determine stellar magnitudes directly from electronic images, and a number of other powerful features.

A Note on Accuracy

Meade Autostar IP was designed to be extremely powerful and accurate. Many programs designed for the PC have taken shortcuts to appear faster, but at the expense of accuracy! Not Meade Autostar IP! By carefully coding each section of the program using 64 bit floating point numbers, Meade Autostar IP takes full advantage of your computer to provide fast and accurate performance. This gives you the power and accuracy that rivals main-frame computer performance.

System Requirements

The minimum system required to run Meade Autostar IP are as follows:

- 64 MB RAM.
- Hard Disk with 20 Megabytes of free space.
- An VGA or better adapter and compatible monitor.
- Microsoft Windows 98SE or above.
- A Microsoft compatible mouse.

Registering the Program

Please take the time to fill out and mail the Registration Card you received with Meade Autostar IP. Registering Meade Autostar IP entitles you to the following additional benefits:

- Meade 's technical support, if you have difficulty using Meade Autostar IP.
- Automatic notification of upgrades or revisions to Meade Autostar IP.
- Automatic notification when new images or data become available.

1. Installation

Autostar IP is installed as part of Meade's Autostar Suite. If you have not yet installed the Suite, consult the quickstart instructions for the complete instructions.

Typcially, when the Autostar Suite CD ROM is inserted in your computer it will automatically begin the install process. If your system has "autoplay" disabled, click on **START**, then click on **RUN**. When the run dialog box appears, type

A:SETUP then press Enter.

The Setup program will prompt you for the desired drive and path in which to install the program and data files. Then it will begin uncompressing the files from the distribution disks and copying them to the appropriate locations on the Hard disk. Make sure you have at least 60 Megabytes of free space on the destination drive.

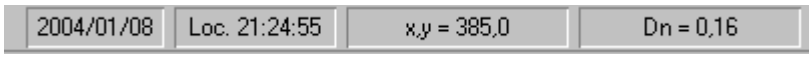
Once the installation is complete, Meade Autostar IP will be ready to help you begin processing your own images.

2. Features

Tool Bar

Autostar IP's Tool Bar gives you immediate access to image files to perform complex image processing with the click of a button.

Status Bar



Autostar IP's "live" Status Bar constantly updates the coordinate display of the image, and the pixel value (Dn.) of the image, as well as the local time. The Status Bar can also be customized under the Preferences command under the File menu.

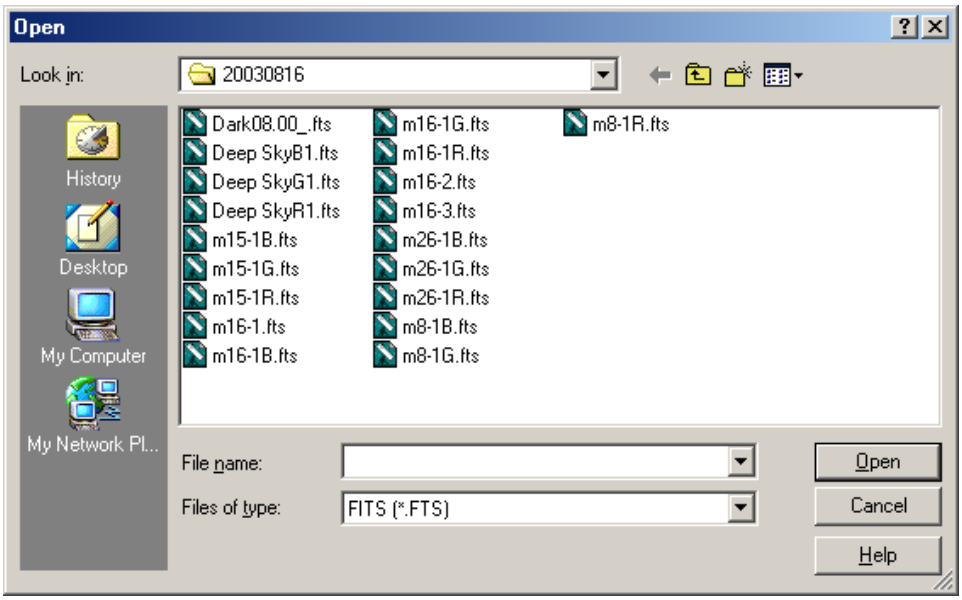
Menu Bar

The familiar Windows Menu Bar gives you access to every function of Autostar IP. To access a drop down menu file, either click with the mouse or press Alt and the letter underlined from the keyboard.

3. File

The file menu contains a number of commands for opening and closing image files, and printing images.

Open



The Open command from the File menu or the button of the Tool Bar allows you open either images or spectrographs in any of the following formats:

TIFF	- Tagged Image File Format (16bit grayscale)
FITS	- Flexible Information Transport System (8 or 16 bit or floating point grayscale)
BMP	- Windows Bitmap Format (8 bit grayscale, 256 color, or 24 bit color)
LNX	- Spectra Source Lynxx format (12 bit grayscale)
ST7	- Santa Barbara Instrument Group (16 bit grayscale)
ST6	- Santa Barbara Instrument Group (16 bit grayscale)
ST4	- Santa Barbara Instrument Group (8 bit grayscale)
08B	- Raw (8 bit grayscale). Similar to ST4.
	In addition there is a RAW format for reading unknown image formats.

Images may only be saved in TIFF, FITS or BMP formats.

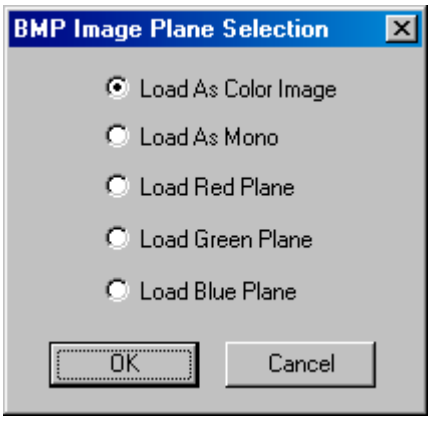
To open a file:

- Select the desired format.
- Select the directory and filename from the list boxes
  OR
- Enter the desired filename in the edit box.

If the filename is specified without an extension, a default extension will be automatically added to the filename to reflect the current format. If the extension is provided, it will over-ride the current selection

Regardless of the file type, the image data will be converted to 16 bit integer data. This assures that high precession is maintained throughout image processing.

If the image is an RGB color image, you will be prompted as to which color plane you wish to load. The following dialog will appear:

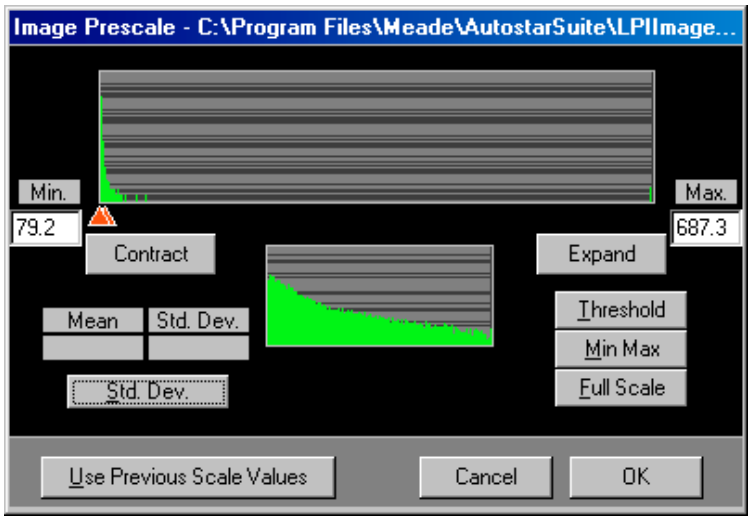


If you select Load As Color Image, the program will load all three color planes and display the image. As an astronomical image processing program, Autostar IP is designed primarily to work on gray scale images. Some of the more advance processing features will not be available when a color image is loaded. If you wish to apply these more sophisticated techniques, load each plane individually, process it and save it in a temporary file. These can later be combined back together to form the desired color image.

8 Bit versus 12 or 16 Bit or Floating Point Grayscale Images

When 12 or 16 bit or Floating point images are loaded, they need to be scaled down to 8 bits (256 gray levels) for display, which is the maximum number of simultaneous gray shades that Windows can display at one time. All of the image information is loaded an processed by the program, but it needs to be scaled down to 256 gray levels for presentation. This scaling is called **Prescaling**. By default the program is options are set to automatically prescale image data. At anytime you can manually prescale the data to suite your taste.

If you elected to disable automatic prescaling, the program displays the **Image Prescale** dialog box when an image is loaded that allows manual setting of the parameters used to compress the data into an 8 bit display format. This dialog box displays the histogram of the raw data in a large graph at the top and, at the bottom, a smaller graph of the resulting data after the display scaling operation.



Although the display shows only 256 levels, all of the image data are retained and processed by the program. Whenever you perform a processing step, you are given an opportunity to rescale the display data. The scale command, also allows you to rescale the image any time you desire.

When prescaling an image, a histogram is constructed that shows the distribution of the data contained in the image. Normally the data is distributed in a rather narrow range of values which lends itself to scaling to the 8 bit format. Once the histogram is constructed, the Threshold values of the data is calculated and are used to set the scaling range. This gives a reasonable starting point for scaling most images. The threshold values may be reset at any time by pressing the **Threshold** button.

Since the data is not evenly distributed, some fine-tuning of the limits is usually needed. This is accomplished by using one of the predefined scaling options or by moving the red markers located under the main histogram display. Generally, the best images are obtained with the markers set just at the high and low edges of the important data. Values that are above the upper marker result in pure white pixels, while those below result in pure black.

If the **Std. Dev.** button is depressed the Mean and Standard Deviation of the image are calculated. The upper limit is set to the Mean plus 5 Standard Deviations, while the lower limit is set to the Mean minus 1 Standard Deviation.

The **Min Max** button sets the pointers to the extreme minimum and maximum values contained in the image, while **Full Scale** sets the values to maximum and minimum values in the image.

If you are loading images from an RGB composite set of files, you may find it useful to use the same scaling values for each of the individual images. This is easily accomplished by using the **Use Previous Scale Values** button located at the bottom the dialog box. Since many astronomical images contain a large amount of red light, you may want to load the red image first, scale it properly, then use the same scaling values for both the green and blue images.

Close

Selecting Close will close the current file and remove its display window and any support windows, such as the Histogram.

Save As Fits Image

Displays the Save As dialog box and allows saving the current image data in a floating point FITS formatted file. This method of saving insures that all of the information in the image is maintained. This is the format recommended for keeping archival copies of your image data.

To save a file:

- Select the directory and filename from the list boxes
  OR
- Enter the desired filename in the Edit box.

If the filename is specified without an extension, a default extension will be automatically added to the filename to reflect the current format. If the extension is provided, it will over-ride the current selection

Export Display As

Saves the currently display image to a file. This function is only available if the current format type is TIFF, FITS or BMP. This command will save the image **as displayed** on your computer as an 8 bit or 24 bit data in the format you request. Saving images this way will allow you to save images ready for use in documents, but will discard part of the original image data

To save a file:

- Select the desired format.
- Select the directory and filename from the list boxes
  OR
- Enter the desired filename in the Edit box.

If the filename is specified without an extension, a default extension will be automatically added to the filename to reflect the current format. If the extension is provided, it will over-ride the current selection

NOTE: All images are saved in the 8 bit versions of their respective format type, Some original information may be lost.

Revert

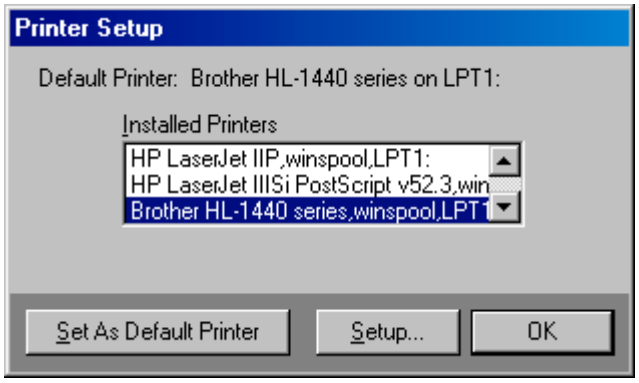
The Revert command allows you to revert the image to the last saved version.

Print

Selecting the **Print** command or pressing the Print button from the Tool Bar prints the current image on the system's default printer. The image is scaled so that it completely fills the printing area of the paper in the horizontal direction. The vertical scale is then chosen to preserve the original aspect ratio of the image. Additional information pertaining to the image is also printed at the bottom of the page, below the image.

Printer Setup

Displays the **Printer Setup** dialog box which allows the selection of any of the currently installed printers.



To alter the print setting on a printer, highlight the printer in the **Installed Printers** window and select the **Setup** button. The printer's control dialog will open an allow you to modify its settings. Finally, if the desired printer is not the systems Default Printer, user the **Set Default Printer** button to assign it as the system default. Remember this change will also affect any other program started after the change has been made.

The most common use of Printer Setup is to allow change between B&W or Color, or portrait and landscape printing formats.

Page Setup

Selecting Page Setup allows you to customize the page to include headers, footers and set margins. You can also select a border.

Exit

Shuts down Meade Autostar IP in an orderly fashion and returns to the Windows Manager. If there are any modified files opened, you will be prompted to save those files.

4.View

The View formatting section allows you to modify how the image data is presented on the display in a number of ways. You can lighten or darken an image, change its contrast, or run a number of sophisticated image processing functions to bring out or suppress subtle details contained in the image. You can change the size of the image, tint its display palette or annotate it.

All of the functions in the View menu affect only the image display, not the actual image data.

To access the commands you can either click on View on the Menu Bar with the mouse, use the Alt key and the appropriate underlined letter from the keyboard, or, when available, click on the appropriate button from the Tool Bar.

Descriptions of the Image file commands from the Menu Bar appear below. The icon from the appropriate button from the Tool Bar also appears next to the description for your reference.

Zoom Image Size

This command allows you to change the *displayed* size of the image. The image can be made larger or smaller depending on your needs. This is generally used to allow an entire image to be displayed even if the original image size exceeds the screen size.

The **Fit Window** button automatically scales the image so that all of the image can be displayed in the current window regardless of the aspect ratio of the window. This means that one axis of the image may not completely fill a portion of the window. You will notice that the Photometry cursor is constrained from using the area outside the actual image area.

Scale

The **Scale** dialog allows you to modify the contrast and brightness of the image in a variety of ways. Scaling is a two step process. The first step is to **Prescale** the image. This selects the range of data to be mapped to the 256 available levels. The second step is final **Scaling** of the image.

Final scaling gives you a broad range of control. You change can be as simple as a straight linear scaling or as complex as Histogram Equalization.

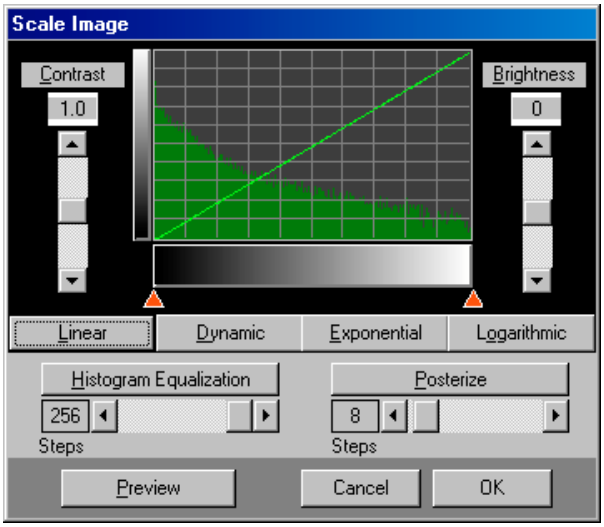
When a new image is loaded, the values in this dialog box are reset to their defaults. This allows you to initially view the image in its un-altered state.

The graph displays the transformation that will be applied to the image values when the **OK** button is depressed. The horizontal axis represents the input values to the transformation, while the vertical axis represents the resulting values. Each axis is drawn to reflect the values of the current palette. With the normal **Linear** transformation each input pixel corresponds to exactly the same output value, but only when Contrast = 1.0 and Brightness = 0.

You can think of the **Contrast** and **Brightness** controls as the variables M and B in the equation of a straight line,

$$Y = MX + B$$

where X is the input value, M is the slope of the line, B is the zero offset and Y is the resulting value. By varying the **Contrast** control you can actually see the slope of the line changing. A steep slope results in an image that quickly varies from black to white (high contrast), while a shallow slope (less than 1.0) produces an image which is made up mainly of gray values. Setting the **Contrast** to a negative value produces a negative image.



Setting the **Brightness** control to values greater than zero brightens the image, while values less than zero will darken it. Generally, you must use both the contrast and brightness controls together to achieve the desired results.

The **Linear** function sets a straight line transformation that resets the contrast and brightness values to 1.0 and 0.0 respectively.

The **Dynamic** function analyzes the image for its lightest and darkest values (excluding pure black and white) then sets up a linear transformation with the contrast and brightness adjusted to provide a full range image. This is useful on images that are over or underexposed, or those that have poor contrast.

The **Exponential** function sets a non-linear transformation and resets both contrast and brightness. The resulting exponential curve produces images that have lower contrast in the dark areas and higher contrast in the light areas. This is useful for bringing out detail in the central regions of galaxies or nebulae.

The **Logarithmic** function produces a curve that is the inverse of the **Exponential**. It increases the contrast in the dark areas while lowering it in the bright areas. This helps to enhance the detail in the faint arms of a galaxy.

The most complex transformation is **Histogram Equalization**. Its purpose is to construct a transformation curve that shows the maximum amount of detail in the image in all areas. This is accomplished by building a Histogram of the image (counting the number of pixels at each brightness level), then constructing a curve that tries to equalize the number of pixels in each of the resulting brightness levels.

The maximum number of resulting levels can be set using the scroll bar, a greater number of steps generally produces a smoother image. This value must be set before the **Histogram Equalization** button is pressed. The maximum value is seldom reached since the equalization process greatly reduces the number of initial gray levels. The default value of 128 is useful in the majority of cases since most images tend to equalize to fewer than 64 steps.

Histogram Equalization is useful in almost all images, but remember that the resulting curve is far from linear, so that further quantitative analysis (e.g., Magnitude determination) is impossible.

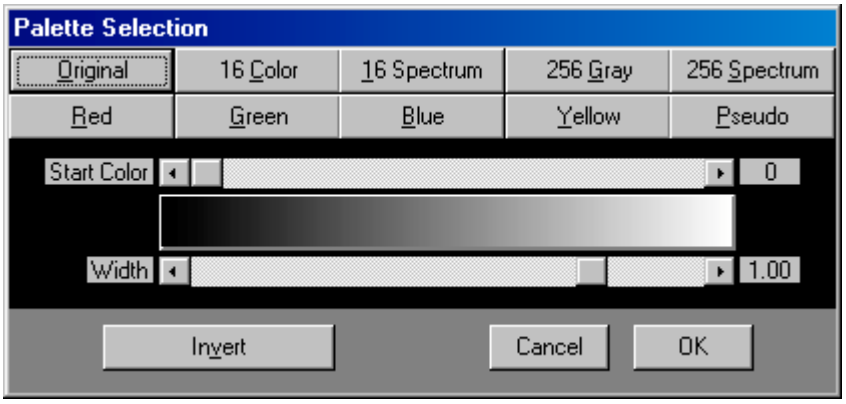
The **Posterize** function produces a stair stepped curve that can reduce the number of displayed values to the predefined settings. By setting the number of steps with the scroll bar, depressing the **Posterize** button displays the resulting curve and resets the contrast and brightness values. This feature is most

useful for delineating areas of similar brightness to enhance the overall shape of an object such as a comet or nebula.

Before committing to the scaling function that you have selected, you can Preview the image by pressing the Preview button, you then have the option to select OK , Cancel , or try another scaling function.

Palettes

The **Palettes** dialog box allows you to modify the original palette of the image or to change the palette to completely different sets of colors



The pushbuttons at the top of the dialog box loads a new palette and resets the positions of the Start Color and Width scroll bars.

The **Original** button resets the palette to the values that were contained in the original image

The **16 Color** button loads the standard 16 colors into the palette. This is useful on VGA systems that are running in 16 color mode. The normal hardware palette values in VGA only support 3 shades of gray, but, by using the **16 Color** palette and selecting the **Grayscale Palette** from the **Options** menu, a full grayscale of 16 colors can be used. This option changes ALL colors on the display (including all other windows) while in a standard VGA 16 color mode!

The **16 Spectrum** button builds a set of 16 colors that smoothly transition from Black, Blue, Green, Red and ending with White. The appearance of this palette varies depending on the current video driver.

The **256 Gray** button constructs a unique grayscale palette that emulates a full 256 color grayscale. The standard Extended or Super VGA 256 color modes only support 64 different shades of gray. Using this new palette results in a smoother image compared to the 64 shades palette. This is accomplished by using color values that vary slightly from the pure gray colors. These off-color values are used to fill-in the steps between the 64 pure gray values. If the **Night Vision** feature is active the **256 Gray** button becomes **256 Red** which allows the image to be displayed in red to preserve your night vision.

The **256 Spectrum** button constructs a 256 color palette that smoothly transitions from Black, Blue, Green, Red and ends with White. This palette is especially useful for bringing out subtle detail in the image.

NOTE: The 256 color palettes, when used in a 16 color mode, will display dithered colors that approximate the actual values. Their appearance in the image may differ greatly depending on the 16 color driver that is currently in use.

Red, Green, Blue, and Yellow buttons construct single color pallet that terminate in white.

The Pseudo button constructs a pallet that contains red, green, and blue values for a generic 8 bit color image.

There are two scroll bars on either side of the palette display. The uppermost scroll bar changes the starting color of the palette, while the lower one changes the width of the palette. Moving the upper scroll bar to the right has the effect of shifting the colors to the right, moving to the left moves the colors to the left. The lower scroll bar allows the current palette values to be expanded or compressed. Moving the lower scroll bar to the right expands the color palette, moving it to the left, compresses it and allows up to 5 cycles of the palette.

*NOTE: If the palette has been inverted using the **Invert** button, the action of these buttons may appear reversed.*

The **Invert** button swaps the colors in the palette end-for-end. This is useful when displaying negative images (those that appear as dark subjects on a light background). The button text changes to **Revert** to indicate that the displayed palette is reversed.

Contour

The contour function allows you to perform an isophote analysis of the current image. This is accomplished by drawing contour lines over the existing image. The spacing of these lines is controlled by the **Contour Interval** value. For example, if the interval is set to 16, then a contour line will be drawn at pixel value 16, 32, 48, etc.. This function is useful when trying to determine the shape of any diffuse object such as a comet or galaxy. Using the **Posterize** function in the Image Scale utility will provide an alternate method that is also useful when determining the shape of an object.

The contour process begins by building an Unsharp Mask of the current image. This is a smoothed (blurred) version of the original image. Then the contouring algorithm is run using the smoothed image. The resulting contour lines are then drawn over the current image. To vary the effect of the contouring, the **Region Size** parameter can be changed to any desired value, a low value (3 or 4) gives a very ragged contour line, a large value (11 or 12) provides a smooth contour. The default value of 7 is useful in most images. You may need to experiment with different values to get the correct response for any given image.

Blink

The **Blink** command allows you to easily detect differences between two images by rapidly displaying first the image, then the other image. When the command is first executed, it first displays each of the images and saves a special copy of each image in memory. It then begins a high-speed toggle of the images using the special copies. The command may be terminated at any time by hitting the Stop button.

This command is especially useful for detecting changes in brightness or position of objects from one image to the next.

To use, load an image from the Open command from the File menu then choose the Blink command from the Image menu. Load the image to be blinked from the Select File option and click on Start. You can then control the Offset Adjust (x/y position of the two images) and the Rate Adjust (blinking speed) in real time.

Note: The images can be of different size images of different orientation.

5.Tools

The Tools section allows you to examine the image data a number of ways. You can examine the image header information, magnify close up sections of the image, view brightness distribution or examine individual pixels.

All of the functions in the Tool menu are for analysis and do not affect only the image display, or image data.

To access the commands you can either click on Tools on the Menu Bar with the mouse, use the Alt key and the appropriate underlined letter from the keyboard, or, when available, click on the appropriate button from the Tool Bar.

Descriptions of the Tool commands from the Menu Bar appear below. The icon from the appropriate button from the Tool Bar also appears next to the description for your reference.

Coordinates

The **Coordinates** function displays a modeless dialog box that continuously shows the current coordinates of the cursor while it is positioned over the image. The value of the pixel under the cursor is also displayed and is updated as the cursor moves.

The pixel value may be displayed in three different formats: the 8 bit integer display value, the scaled floating point value or the 16 bit unprocessed value. The 16 bit format is only available for 12 or 16 bit images when the 16 bit data is resident. The mode can be chosen by selecting either the **Integer, Real,** or **Unprocessed** button located at the bottom of the dialog box. See the **Image Prescale** function for details on keeping the 16 bit data resident.

The coordinate dialog box must be active if you wish to make distance measurements from the image. The **Dist.** field will display the distance value after the **Set Distance Ref.** function has been selected from the **Image Utilities** dialog box.

Histogram

Displays a bar graph of the number of pixels in each of the 256 colors or shades of gray. The graph is automatically scaled, and displayed in a logarithmic format.

The *Max* field at the top of the display indicates the maximum number of pixels contained in any of the colors. The background grid is logarithmically scaled. The lower group of 10 lines indicate the values from 1 to 10, the next group indicate the range from 10 to 100, the next group is 100 to 1000, and so on.

The histogram is automatically updated whenever the image values have been modified.

Magnifier

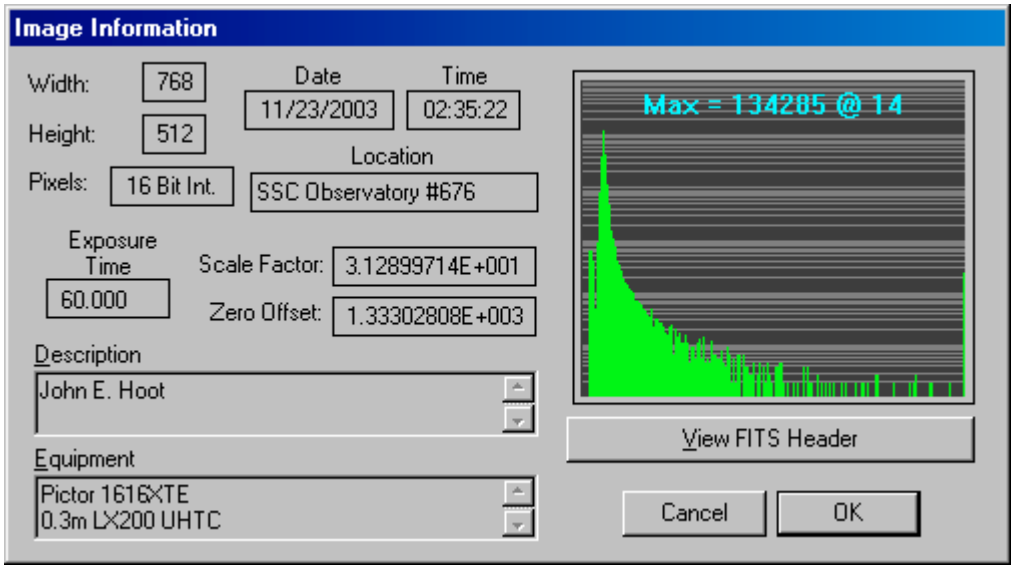
The **Magnifier** allows you to zoom into any portion of the display to observe small details. If an image is displayed when the magnifier is turned on, the default starting location is the center of the image, otherwise it uses the center of the client area of the main window. A new area can be selected by moving the cursor onto the magnifier's
window, depressing the *left* mouse button, then, while still holding the left button, move to the desired area.

The magnification factor can be changed by moving the scroll bar located on the right side of the magnifier window. The magnification range is 1.0 to 32.0 in steps of 0.1. The default magnification is 4.0.

The size and location of the magnifier window can be modified using the standard methods.

Information

Displays general data about the current image, such as, size, scale factors, date of image, location, etc.. Most of this data is a permanent part of the image and can be found in the headers of the various formats. Only the size and bits per pixel values are saved in the BMP format. The FITS and TIFF formats save all of the information.



The **Scale Factor** and **Zero Offset** fields contain the factors used to convert the image from the orignal data to an 8 bit image.

The View FITS Header option allows you to determine the information file contained within a FITS image.

Also displayed is the image's histogram.

6.Process

The Processing section allows you to modify the actual image a number of ways using advanced image processing commands. Since the commands change the actual image data, this menu section features an UNDO command that will allow you to restore the image data to the its state prior to the previous command.

To access the Process commands you can either click on Process on the Menu Bar with the mouse, use the Alt key and the appropriate underlined letter from the keyboard, or, when available, click on the appropriate button from the Tool Bar.

Many of the image processing functions also allow for a preview so that you have the option to choose a different variation of the function , choose OK, or to Cancel the function. The functions that offer the Preview option are: Merge, Convolution Filters, Unsharp Masking, and RGB merge.

Descriptions of the Processing commands from the Menu Bar appear below. The icon from the appropriate button from the Tool Bar also appears next to the description for your reference.

Undo

Resets the image variables to its previous values and re-displays the image. You can only 'Undo' the last operation that affected the image data.

Calibrate

Select Bias Frames, Dark Frames, or Flat Field Frames for calibrating the image that is currently loaded and displayed. Each of the three calibration types can be used singly or in combination.

Merge

The Merge Image command allows y you to select an image from the Merge File to perform a Merge Function. You can select; Add, Subtract, Average, Median Combine, Multiply, Divide, And, Or, and Exclusive Or functions. There is also the option to select x/y offsets, and Scale Factors of the Image File and Merge File. (For a straight add or subtract both of these Scale Factor values should be set to 1.0.)

Correct Column Defect

Perfect solid state image sensors are difficult to make. Often units are produced that have one or more columns that do not work correctly. These engineering grade sensors are often used in commercial CCD cameras. The processing command allows you to replace a defective imager column with the average of the two adjacent columns. When the command is selected a dialog box will prompt you to enter the number of the defective column. Once this is done and confirmed, the column is replaced.

Flip Image

The currently displayed image may be flipped either vertically or horizontally. This allows the image to be shown in its actual orientation if the telescope or camera system causes the image to appear inverted. The **Vertical** and **Horizontal** flipping function may also be used in combination.

Rotate Image

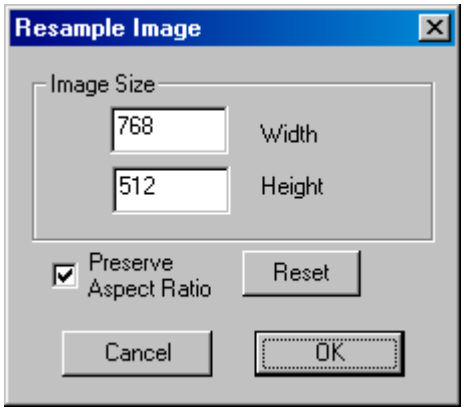
The currently displayed image can be rotated in steps of either +90 degrees (counter-clockwise) or -90 degrees (clockwise) using the **Rotate Image** command.

Rotate Image must physically move the image data from one axis to the other. This changes the orientation of the image in memory, therefore, subsequent buffer functions, such as merging, may not

function properly. To preclude these problems, the contents of the buffers are destroyed before the rotation takes place. You should then copy the rotated image into the desired buffer(s). After the command is complete, the newly rotated image is automatically copied into Buffer A.

Resample

The **Resample** command changes the actual size of the image. This allows you to make an image larger or smaller. Unlike **Resizing** which only affects the display, this command actually manipulates the image data make it a new size. When you select this command, the following dialog appears:

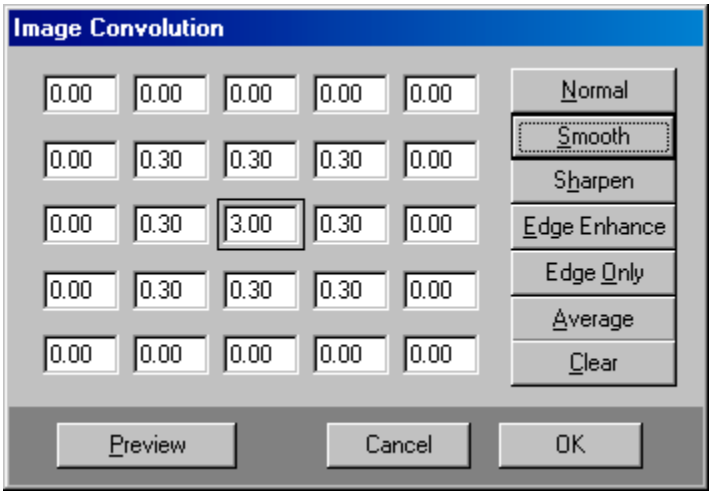


To change the size of the image, just enter the new dimensions desired. If the **Preserve Aspect Ratio** switch is set, Any time you enter either the width or height, the other number will be adjusted to perserve the aspect of the image. With the switch off, you can maker changes that will alter the aspect ratio of the final image. When you click on **OK**, the image will be modified.

Remember, when you reduce the size of the image, information will be lost.

Convolution Filters

The **Convolution Filter** dialog box displays the kernel values of the current convolution filter and allows you to select from a list of pre-defined kernels or to enter your own values. See the Appendix for a description of image convolution.



The **Normal** button constructs a filter that does not alter the original image when the convolution process is started. This allows you to reset the kernel to a normal starting point when you are constructing your own kernels.

The **Smooth** button builds a kernel that subtly blurs the image, reducing the effect of any noise that may be present in the image. Lowering the value of the center number in the kernel increases the smoothing effect. While increasing the value reduces the effect.

The **Sharpen** button is useful in bringing out the details in images that originally appear somewhat blurred. This effect is different than **Unsharp Masking,** but can appear similar in some images.

The **Edge Enhance** and **Edge Only** kernels are quite similar except for the value at the center of the kernel. Their effect is to enhance the appearance of any edges (transitions) from light to dark. The **Edge Enhance** maintains the overall appearance of the image, but modifies the edges, while the **Edge Only** filter displays only the edge modifications.

The **Average** button merely sets all of the kernel values to 1.0 resulting in a 5x5 pixel average (blurring) of the image. The **Clear** button sets all the values to 0.0. This can be used to set the starting values in your own custom filter.

To **Preview** the effect of your filter on the image, click the preview button. Adjust the parameter until you achieve the desired effect, then click **OK.**

Unsharp masking

This powerful command allows you to bring out the subtle detail that is normally not visible in the unprocessed image. When this command is selected, the **Unsharp Masking** dialog box is displayed. This allows you to set the region size used to produce the blurred unsharp mask. The larger the region size, the more unsharp (blurrier) the resulting mask becomes. This allows details smaller than the region to be enhanced after the mask and the image are merged.

You can try other values for the **Scale Factors** to increase or decrease the effect of the unsharp masking technique. The only requirement is that the value for the image must be 1 greater than the value for the mask. Try values such as: 5,4 or 6,5 to increase the effect, or 2,1 to decrease the effect.

NOTE: The original values of the **Scale Factors** are left untouched.

Median Filter

Median filtering modifies an image by replacing each pixel with the median (middle value) of it and all of its neighboring pixels. It is useful for removing random noise, and some column defects. Works on single pixel artifacts and smoothing out a generally noisy image.

Fix Hot Pixels

Even after calibration, images often have individual pixels that are too bright. These can be a result of read noise from your camera, cosmic rays that hit your imager during the exposures, slight errors in your calibration images. Regardless of the cause, this filter will look for these single pixel anomalies and remove them. When you select this command, a dialog box will appear. This dialog allows you to set how aggressively the program hunts for bad pixels. The smaller the threshold number you supply, the more aggressively, the filter will act.

Fix Cold Pixels

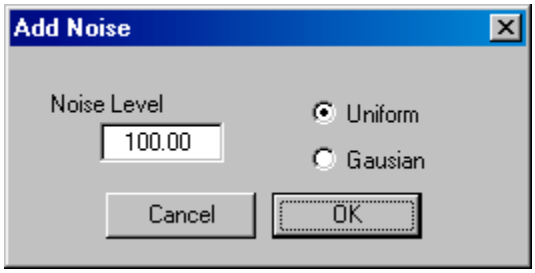
Even after calibration, images often have individual pixels that are too dark. These can be a result of read noise from your camera, cosmic rays that hit contaminated your dark frams, slight errors in your calibration images. Regardless of the cause, this filter will look for these single pixel anomalies and

remove them. When you select this command, a dialog box will appear. This dialog allows you to set how aggressively the program hunts for bad pixels. The smaller the threshold number you supply, the more aggressively, the filter will act.

Add Noise

This command can be used to make cosmetic improvement to an image's appearance. Adding a small amount of noise can cover up minor defects. It can also disguse the problem of areas with gradual changes in brightness; the human eye is very effective at detecting the shift from one color level to the next, resulting in a banded or contoured appearance (Mach bands). This problem can sometimes be seen on planetary limbs, or in solar limb darkening. This visual effect can be eliminated by adding a small amount of random noise.

When you select this command the following dialog appears:



Use this dialog to select the mean amplitude of the noise you wish to add to the image. Additionally, you can select the distribution of the noise added. The noise can be wither uniformly distribute (white) noise, or gausian noise. When you click on **OK,** these random values will be added to each pixel in your image.

Stretch Image

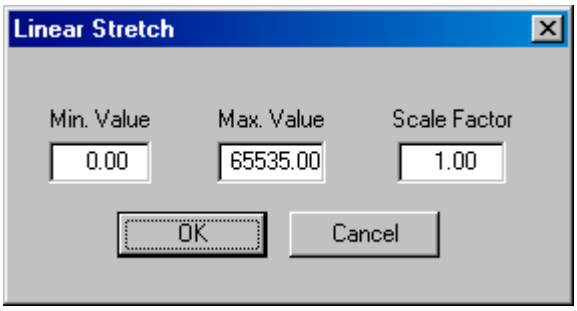
Stretching a image is the process of applying an algebraic function to each pixel in an image. This process can be used to emphasis or de-emphasize highlights, or simply clip and scale image values. Autostar IP offers several different scalings:

Log Scaling replaces each pixel with the log of its value. This has the effect of stretching the contrast to favor details in the image highlights and increases the dynamic range of the image that can be displayed.

Exponential Scaling replace each pixel with the **e** *(the base of the natural logs)* raised to the power of the pixel value. This stretch flattens detail in highlights. It is also helpful in reducing limb darkening effects.

Gamma Scaling replaces each pixel with its square root. This stretch is similar in its effect to log scaling, but is not as aggressive. It helps increase the dynamic range of an image.

Linear Scaling, when selected brings up the following dialog box:



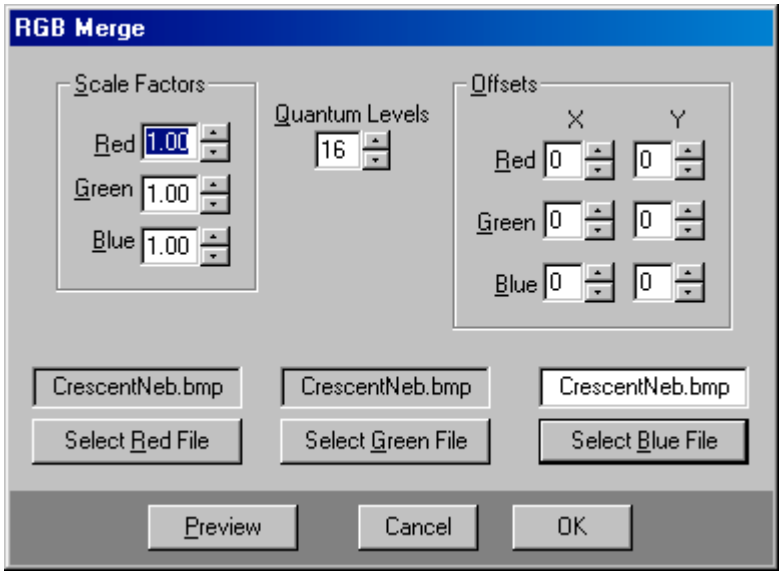
Linear scaling performs the following transformation:

Final Pixel = (Pixel – **Min.Value**) * **Scale Factor**

If the Final Pixel is greater than **Max. Value**, the Final Pixel is assigned the **Max. Value.**

RGB Merge

The **RGB Merge** command produces a full color image by combining three separate grayscale images, one exposed through a red filter, another exposed through a green filter, and the last exposed through a blue filter If your system has 16 or 24 bit color modes, these images can be directly combined, otherwise this is accomplished by analyzing all of the possible colors in the image, then using a proprietary algorithm to choose the best colors to take full advantage of the 256 color system palette.



The **RGB Merge** command also allows you to modify the color balance of the final color image. Increasing the scale factor for an individual color, increases the intensity of that color in the resulting image, decreasing the scale factor decreases the overall intensity of that color in the image.

Each of the scale factors can be used separately or together to achieve any desired color balance. For example, if the resulting image is too magenta, you might try lowering BOTH the red and blue scale factors, or you may try increasing the green scale factor to achieve the same effect.

The scale factors may also be automatically determined by using the **RGB Gray Balance** function from the **Image Utilities** dialog box. To automatically balance the colors in the image, first locate an area in the image that should be white, or any neutral gray value such as a medium brightness star. Then draw a box around the object by depressing the **left** mouse button and dragging the box to the desired size. When the button is released, the **Image Utilities** dialog box will be displayed. If all three RGB buffers contain valid images, the **RGB Gray Balance** item will be enabled. Upon selecting the **RGB Gray Balance** function, the scale factors for each color will be determined and will automatically merge the buffers to produce a new image. The resulting image will show your selected object as a shade of gray.

On 256 (8 bit) color systems, the **Quantum Level** field allows you to influence the behavior of the color selection algorithm. If the resulting image contains a very large number of colors, lowering the Quantum Level decreases the number of resulting colors. Similarly, raising the value increases the number of colors, up to the maximum number of colors contained in the image. When the number of colors found in the resulting image closely matches the number of colors used in the image, you will notice a marked increase in the speed of the merging process.

When the command is complete, the number of colors that were found and the number of colors used in the resulting image are displayed. You should modify the number of Quantum Levels (in the RGB Merge dialog box) so that the two values are fairly close together. Generally, finding 300 to 400 colors results in the best image. Using a large number of colors results in an image that has a very small change in colors, using fewer colors increases the color differences seen in the image

The resulting color image has its own unique palette, subsequent image processing, such as scaling, generally gives poor results. You should first scale the individual red, green, or blue grayscale images, then combine them using the **RGB Merge** command.

To preserve the color palette, the color image must be saved in the BMP format.

Frequently, many composite RGB images are not perfectly registered, the telescope may have moved between the exposures. This results in one or more of the images being offset from the other images. The Offsets {XE Image:Offsets} the X (horizontal) direction or the Y (vertical) direction one pixel at a time for each of the Red, Green, and Blue image files.

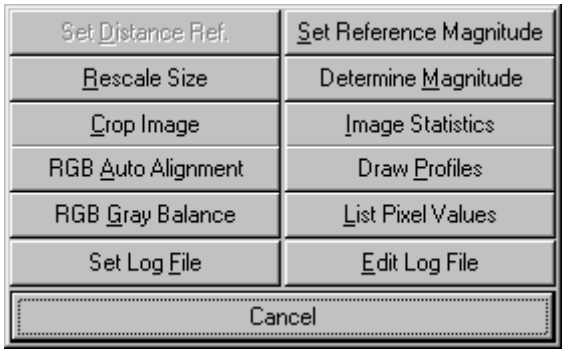
After the image is first merged, you should examine some prominent part of the image using the **Magnifier**. If color fringes are noticed over the entire image, one or more of the separate images needs to be aligned with the others. Count the number of pixels that the images appear to be offset, then set the value in the appropriate red, green or blue X or Y offset fields. When the images are re-merged, the new offset values will be used.

If the images were taken from a telescope that was not properly Polar aligned, the resulting images may also show some rotation from one image to the next, The RGB alignment may help reduce the effect slightly, but cannot correct for the rotation.

The individual offsets may also be automatically determined by using the **RGB Alignment** function from the **Image Utilities** dialog box. To automatically align the images, first locate an area in the image that contains a well defined single object, such as a star. Then draw a box around the object by depressing the **left** mouse button and dragging the box to the desired size. When the button is released, the **Image Utilities** dialog box will be displayed. If all three RGB buffers contain valid images, the RGB Alignment item will be enabled. Upon selecting the auto alignment function, the X and Y offsets for each image will be determined and will automatically merge the buffers to produce a new image.

7. Image Utilities

The **Image Utilities** dialog box can be displayed by moving the cursor over the desired area of the current image and either clicking the **left** mouse button or by depressing the **left** mouse button, drawing a rectangle, then releasing the button. Clicking on a point in the image will enable the **Set Distance Ref.** function, drawing a rectangle enables the **Rescale Size** and **Crop Image** functions. If the three RGB buffers are loaded, the **RGB Auto Alignment** and **RGB Gray Balance** functions will also be available after the rectangle is drawn.



The **Set Distance Ref.** function allows you to measure distances, in pixels, from one point in the image to another. The image **Coordinates** display must be active to use this function.

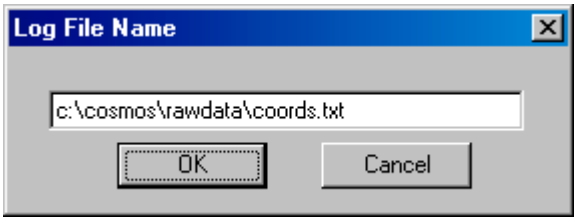
Choosing this command, removes the dialog box, then draws a line from the distance reference point to the current cursor position. As the cursor is moved, the current coordinates and the distance values will be continuously updated. Clicking the **left** mouse button, turns-off the distance measuring feature.

The **Rescale Size** command scales the image to approximately fill the current image window with the data contained within the previously drawn rectangle. This command affects only the display of the image, not the actual data.

The **Crop Image** command removes the data outside of the rectangle, preserving only the data on the inside. This command allows you to remove extraneous data from around the important part of your image. Since this command physically changes the size of the image, any existing data contained in the buffers is destroyed.

See the **RGB Merge** command for a description of the **RGB Auto Alignment** and the **RGB Gray Balance** functions.

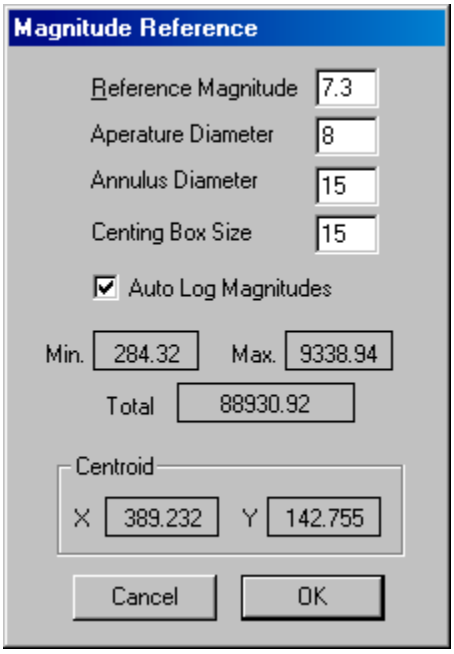
The **Set Log File** command allows you to name a text file where information about the image can be written. Several operations including, **List Pixel Values, Draw Profiles, Image Statitics, Determine Magnitude,** and **Group Photometry** can write information to the Log file. This information can then be used in spread sheets or by other analysis tools. When you click on this button the following dialog appears:



Here you can specify where to write the log file. If the file already exists, you will be prompted to indicate whether you wish to append data to the existing file, or to erase it and start again.

Set Reference Magnitude

To calculate the magnitude of any object in the current image, you must first select an object whose magnitude is already known. Draw a selection box around the object. Then select the **Set Reference Magnitude** function. The following dialog will appear.



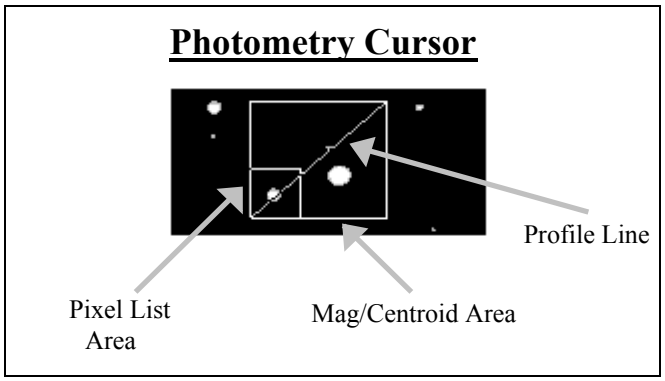
All magnitude calculations in Meade Autostar IP are based on a technique called Aperture Photometry. This method comparing the total energy inside a measurement radius around a target object with that within the aperature of the reference object. Total energy is defined to be the sum of all pixels the aperature less the average sky brightness times the number of pixels in the aperture. The sky brighteness in determined by measuring the sky background in an annulus about the object. This dialog allows you to select the size of the aperature and annulus for measurements.

Additionally, the aperture is centered on your target before the measure measurements are made. The size of the box used to centroid your object for centering is also configurable in this dialog. Finally, if you check the **Auto Log Magnitudes** box, all measurements are automatically written to the log file for export to spread sheets or other analysis programs.

Determining Magnitude

To perform photometry, draw a box around the area that you wish to determine by moving the cursor to the upper left corner of the region, depress and hold the **left** mouse button, then drag the opposite corner of the box to the other side of the object. Release the button when you are satisfied with the appearance of the photometry region cursor.

The Photometry region cursor has three main components: the Magnitude/Centroid area, the Pixel list area, and the Profile line. The Magnitude/Centroid rectangle bounds the entire area used in the magnitude and/or centroid calculations. This area can be as large as the entire image if desired. Finally, the Profile line delineates the pixels that will be displayed when the **Draw Profile** function is selected.



The **Utilities Box** is displayed when the **left** button is released.

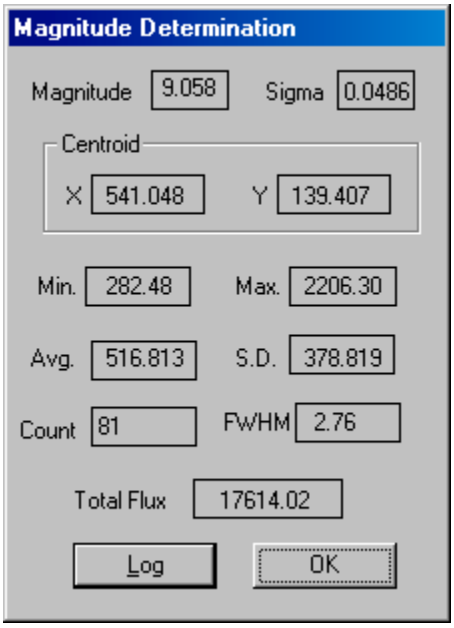
Now choose the **Determine Magnitude** function. You should pick a well defined object, such as a star, whose values are below the maximum set by the size of the data format. A warning message will be displayed if the selected region contains any pixels that are at the maximum. Erroneous values will result if you use objects that contain these pixel values since the actual brightness of these pixels in unknown.

Using the previously set value of the reference magnitude, the **Determine Magnitude** calculates the total energy as in the **Set Reference Magnitude** command, but displays the magnitude of the currently selected region defined by the following equation:

$$RefMag + \left(\sqrt[5]{100} * \log_{10}\left(\frac{RefTotal}{Total} \right) \right)$$

Where,
RefMag is the previously set reference magnitude
RefTotal is the total energy in the reference aperture.
and Total is the total energy in the currently selected aperture.

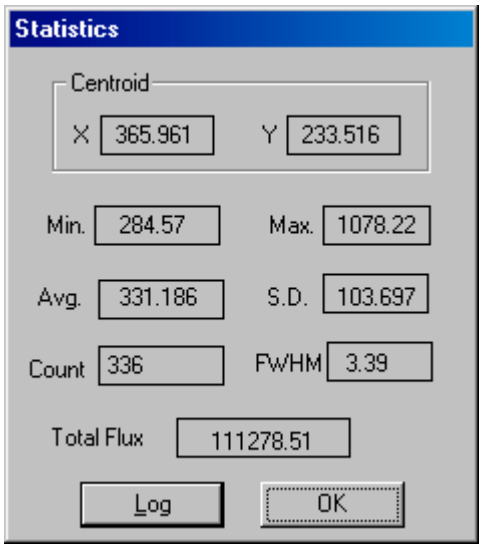
After a moment the following dialog will appear:



This dialog show the result of your magnitude determination. Not only is the magnitude displayed, but the error of the measurement and other pertenant information is displayed. If **Auto Log Magnitudes** is not set, you can still write the results to the log file by clicking on the **Log** button.

Image Statistics

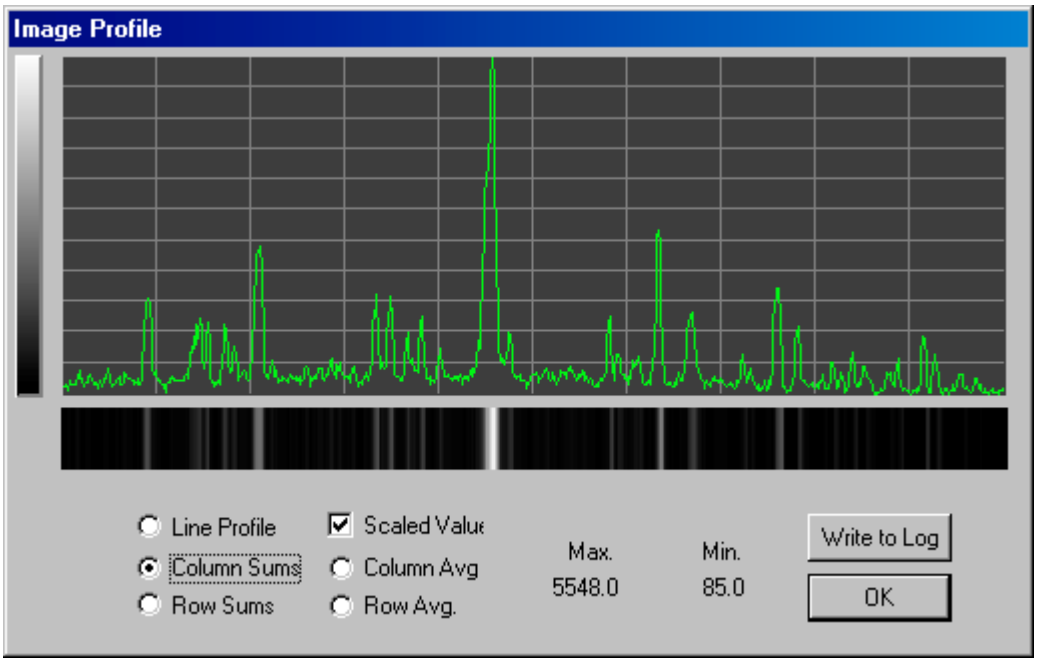
The **Image Statistics** function is similar to the magnitude functions except that it displays only the the statistical information about the selected region. Additionally, Image statistics are calculate over the whole selected region, not just within the photometric aperture. An example result dialog is show below:



Click **OK** to dismiss the dialog. Click on **Log** to write these values to the log file.

Draw Profile

The selection box determines the values to be included in the profile dialog. When **Draw Profile** is selected a Profile dialog similar to the one below is displayed.



If the **Line Profile** button is selects, the diagonal line drawn through the Photometry Cursor indicates which pixels will be graphed by the **Draw Profile** command. Other choices are the summation of the rows, average of the rows, summation of the columns or average of the columns. If the **Scaled Values** box is checked, the screen's display values are used, otherwise the image pixel values are used to generate the profile.

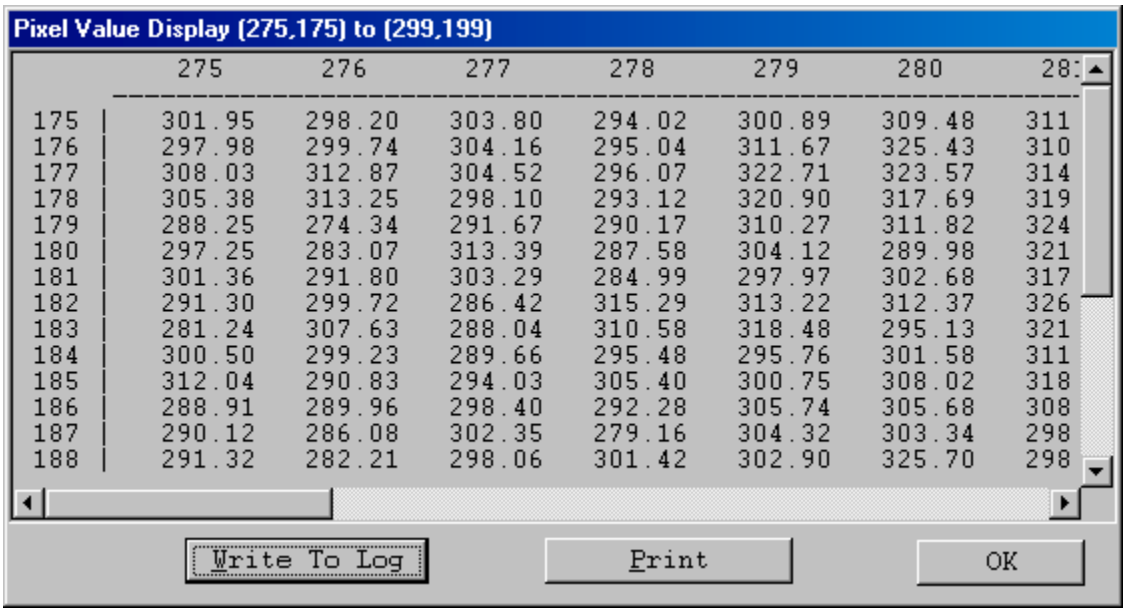
When this function is selected, a linearly scaled graph will be drawn which is automatically scaled to display the entire range of the pixel values along the line. The left side of the graph displays the pixels values at the start of the cursor box. Since you may draw the box in any orientation, you must keep track of the starting point.

The profile graph is useful for viewing spectrographic data, or for viewing trends in the data, such as limb darkening in a planetary image.

To write out the profile as a table of values to the log file, click on the **Write to Log** button.

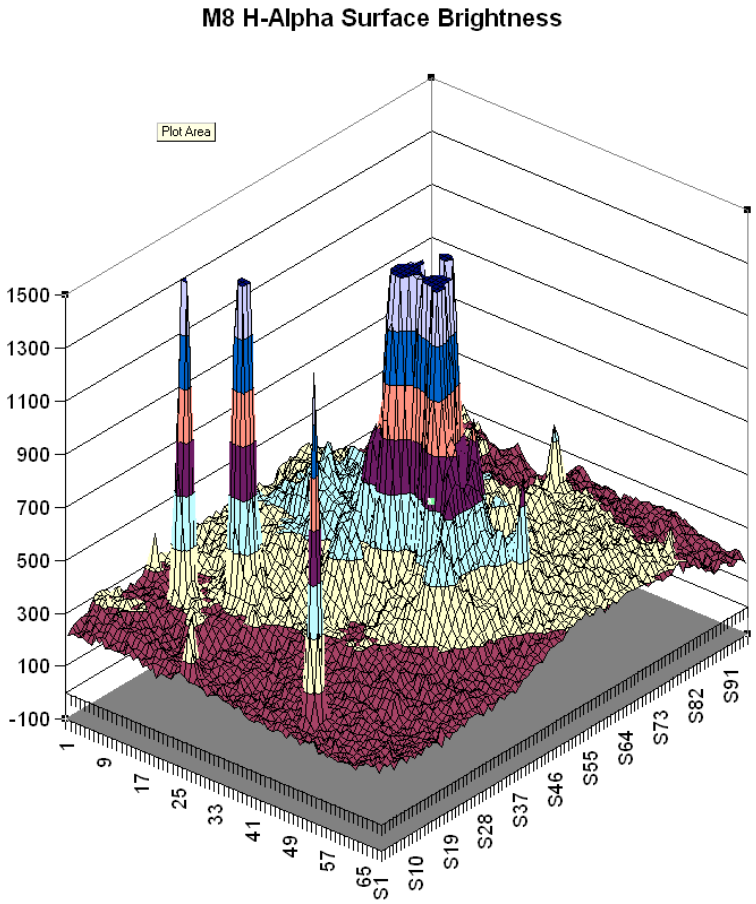
List Pixel Values

The **List Pixel Values** function displays the values of the pixels contained within the smaller box located in one corner of the overall cursor rectangle. The maximum size of the pixel list area is 25x25 pixels. If the cursor rectangle is smaller than 25x25 pixels you will see only one rectangle. You will then see only those pixels contained within the entire region.



The pixel values displayed are the actual image pixel values. If you click on the **Print** button, these values will be printed on the default system printer. If you click on **Write to Log**, the pixel values for the whole selected area, not just the 25x25 box, will be written to the log file in this tabular format. This allows you to export large areas of the image to spread sheets or other software analysis tools.

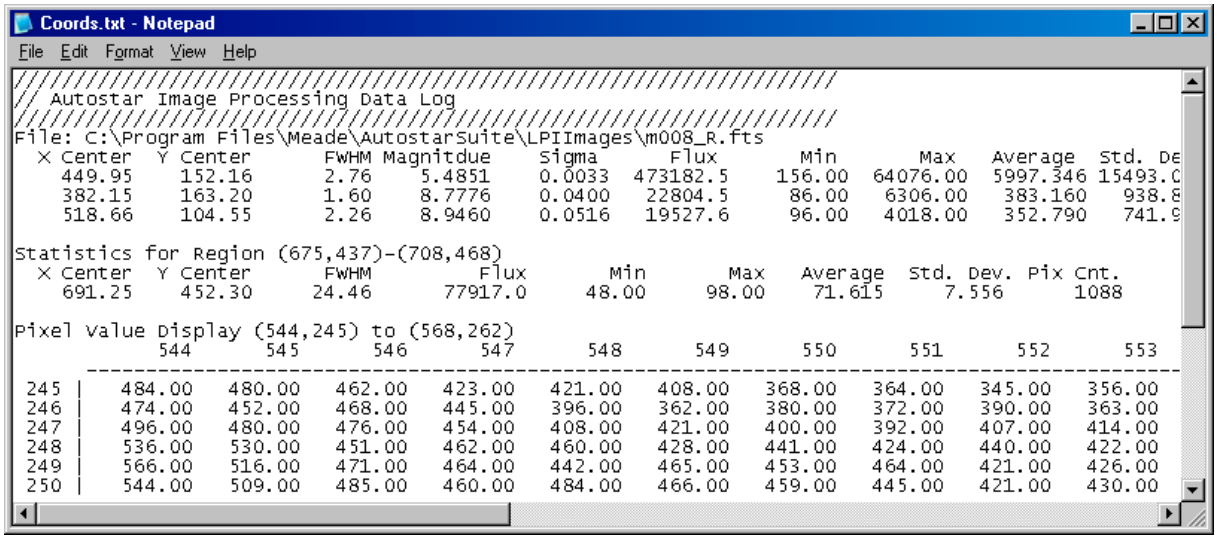
One common use of these exported files is to create 3-D surface plots in spread sheets such as Excel or Star Office.



Edit Log File

The **Edit Log File** command opens the current log file for editing with either wordpad or notepad. This allows you to add annotations to you log file as you work though and image, or to remove unwanted data that may accidentally have been written to the file.

The sample below shows what a typical log file might look like.



Coords.txt - Notepad

File Edit Format View Help

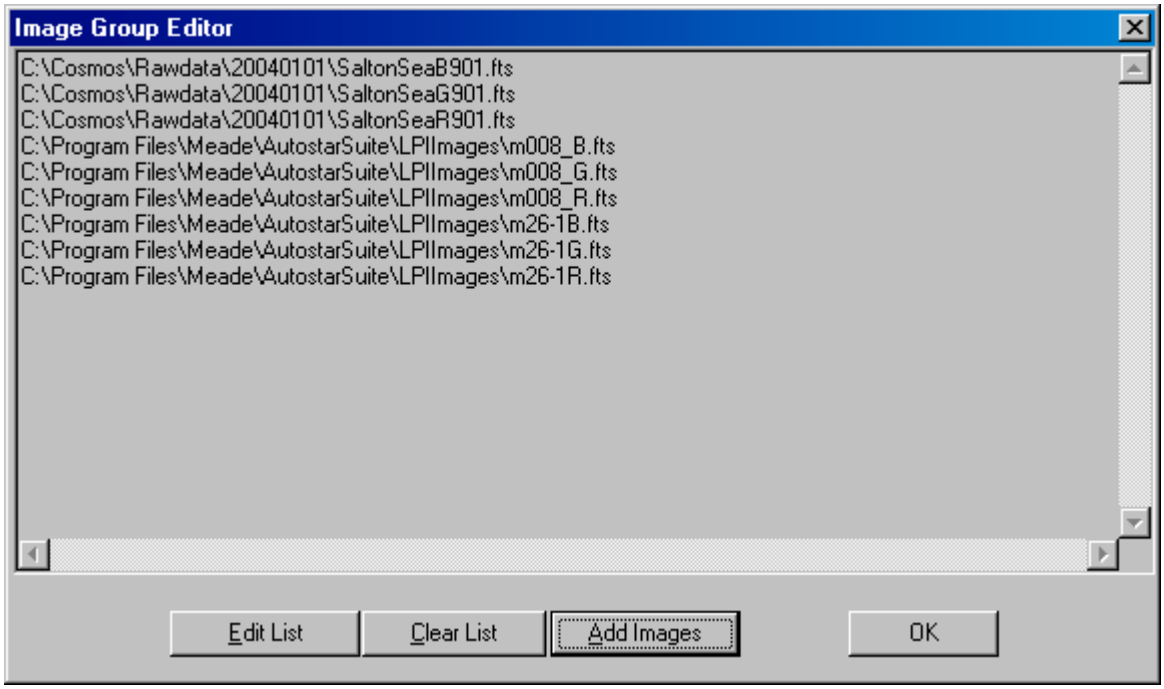
```
////////////////////////////////////////////////////////////////////////////
// Autostar Image Processing Data Log
////////////////////////////////////////////////////////////////////////////
File: C:\Program Files\Meade\AutostarSuite\LPIImages\m008_R.fts
  X Center  Y Center      FWHM Magnitdue    Sigma      Flux       Min       Max   Average  Std. De
    449.95    152.16      2.76    5.4851   0.0033  473182.5    156.00  64076.00  5997.346 15493.0
    382.15    163.20      1.60    8.7776   0.0400   22804.5     86.00   6306.00   383.160   938.8
    518.66    104.55      2.26    8.9460   0.0516   19527.6     96.00   4018.00   352.790   741.9

Statistics for Region (675,437)-(708,468)
  X Center  Y Center      FWHM         Flux       Min       Max   Average  Std. Dev. Pix Cnt.
    691.25    452.30     24.46      77917.0     48.00     98.00    71.615      7.556      1088

Pixel Value Display (544,245) to (568,262)
            544       545       546       547       548       549       550       551       552       553
      ------------------------------------------------------------------------------------------------------
 245 |    484.00    480.00    462.00    423.00    421.00    408.00    368.00    364.00    345.00    356.00
 246 |    474.00    452.00    468.00    445.00    396.00    362.00    380.00    372.00    390.00    363.00
 247 |    496.00    480.00    476.00    454.00    408.00    421.00    400.00    392.00    407.00    414.00
 248 |    536.00    530.00    451.00    462.00    460.00    428.00    441.00    424.00    440.00    422.00
 249 |    566.00    516.00    471.00    464.00    442.00    465.00    453.00    464.00    421.00    426.00
 250 |    544.00    509.00    485.00    460.00    484.00    466.00    459.00    445.00    421.00    430.00
```

8. Group Operations

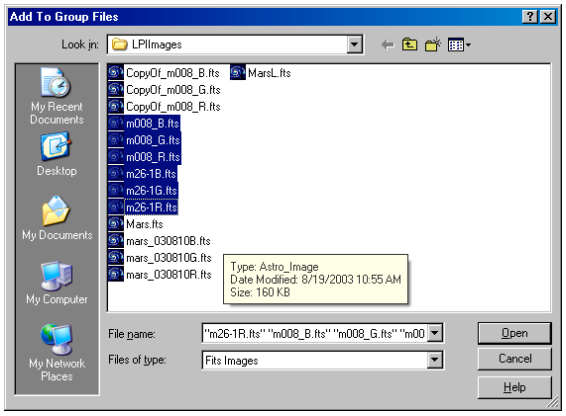
The **Group Operations** menu contains commands that will allow you to process groups of files simulaneously. There are many tasks such as calibration, image combination, alignment and filtering where the same task may need to be done to a whole collection of images. The ability to operate on groups of images is one of the keys to making Autostar Image Processing the most convenient Windows image processing system.

Group Edit

Selecting the **Group Edit** command opens the group editing dialog window that allows you to manage your image group. An Image group is nothing more than a list of files. This dialog allows you to add and delete file names from the list.



To erase the list and start over, select **Clear List.** To add images to the list, select **Add Images.** This will open a standard windows explorer file selection dialog box. You can use this box to select a single file to be added to the list, or by holding down the Shift or Ctrl key when clicking, you can select multiple images to be added to your group.



When you are satisfied with your selection, click **Open** to add them to the current group.

Copy

The **Copy command** will duplicate all of the files in the list. The new file have named that begin with the phrase "Copy_Of_". Often, you do not want to operate on your original data, this makes it easy to create backup copies to work on. Copy will also change your group list to point to the copies as a side effect of this operation.

Examine

The **Examine** command allows you to quickly flip through, inspect and analyze a group of images. When this command is selected, the dialog below will appear in the upper right corner of the program window.

By clicking on the direction buttons you can quickly flip through you images. To exit the examination process, just click on **Cancel.**

Delete

After process images, you often will hve intermediate results images you wish to erase. The **Delete** group command is a fast easy way to clean up. Use the **Edit** command to gather all you scrap files into an image group, then select **Delete.** You will be prompted to confirm your delete. If you reply **OK**, all the files in the group will be moved to the recycle bin.

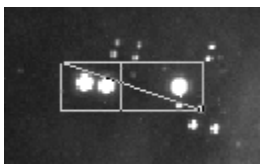
Calibrate

The **Calibrate** command will bring up the Calbirate Dialog box, just as described in the Process section of this manual. After the calibration files have been designated, the files will be applied to every image in the current group.

Align

The **Align** command allows you register and align all of the images in the current gourp to a single object. When the command is selected all of the images in the group together are summed together to for a working image. This image is displayed. If the scope has drifted slightly between the images, the combined image will show multiple stars or trails similar to the section shown below:

The image fragment below shows clearly how all of the star are trippled. To align them, simply draw a selection box around all the stars that should be co-aligned.



The program will go through all of the images an shift them so that they will be aligned on the select star. After the the images have been aligned, a proof image will be created by averaging together all of the images in your group and displaying the results. It may take a couple of interrations to get all the images to line up if you are working in a crowded star field. The technique will work best if the alignment star is in a relatively isolated portion of the image.

Combine

The **Combine** command is used to combine all of the images in the group into a single image. There are several different combination methods available.

Sum adds all the images together.

Average averages all of the images together.

Median takes the middle value of all the images at each pixel location. This method will drop out cosmic ray hits and other random noise from a group of images although the processing can be somewhat lengthy.

Minimum takes the smallest pixel value of all the images at each pixel location.

Maximum takes the largest pixel value of all the images at each pixel location.

Filter

The **Filter** command allows you to apply any of the filter techniques found under **Process** to the entire group of images. Filters available include:

Convolve
Median
Unsharp Mask
Fix Hot Pixels
Fix Cold Pixels

Normalize

The **Normalize** command processes all of the images in the group so that their mean value is 10,000 ADUs. This command is most commonly used to prescale sky or twilight flats before median combining them to drop out stars, satellites and other transient effects.

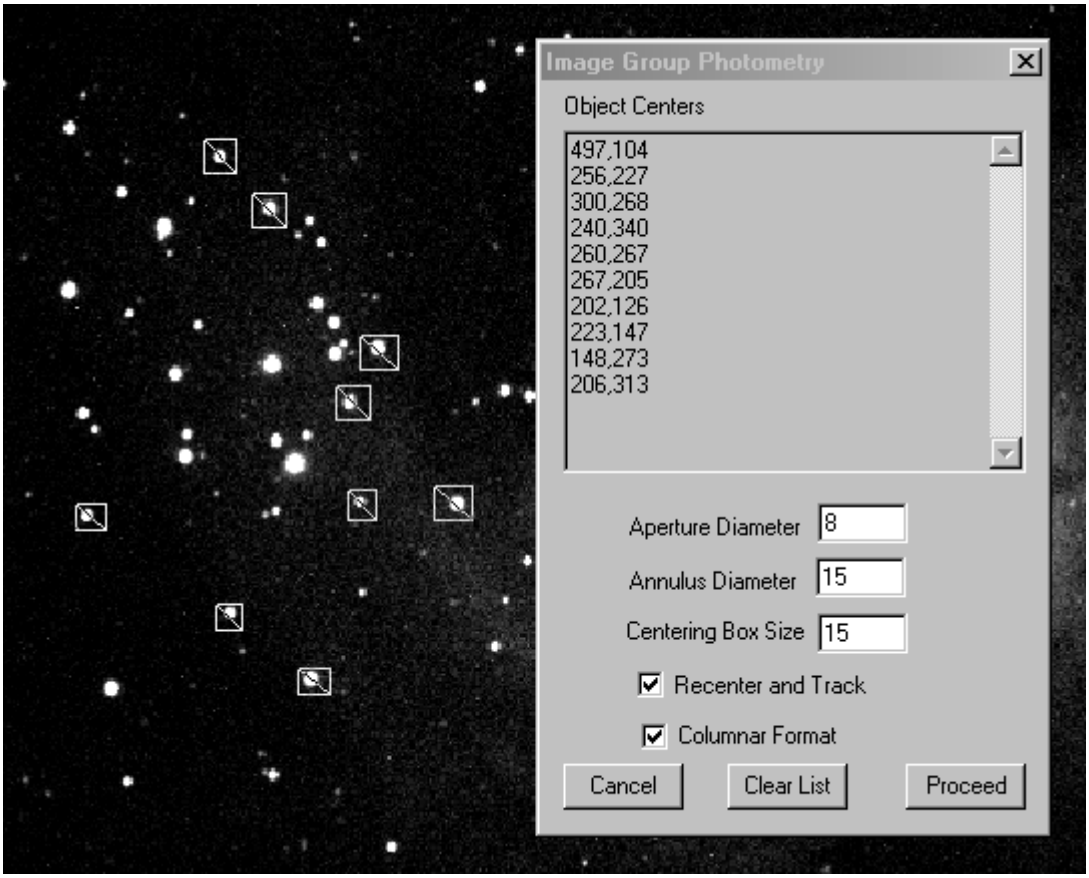
Fix Column Defect

The **Fix Column** command, fixes bad columns in all the images of the group. If functions as described in the **Process** section of this manual.

Photometry

The group **Photometry** command allows you to measure a large number of stars in group of images. It makes variable star, extra-solar planet transit searches, asteroid rotation and comet study easy. In all of these activities, you may have a large number of images of the same field of view taken at different times where you wish to measure the same group of objects in each image.

When this command is selected the group photometry dialog will appear similar to the example shown below. Additionally, the first image in your group will be displayed behind it. Select all the objects that you wish to measure by drawing a box around them.



The center coordinates of the locator boxes are shown in the window at the top of the dialog. Additionally, you can change the aperture and annulus of measurement.

If you check the **Recenter and Track** box, each object will be recentered in each succeeding image. This allows you compensate for slight shifts of the telescope between measurements,. Additionally, for aligned images, it will allow you to track a comet or asteroid as it moves through the field of view.

Since it is likely you will be using this data in other program, chekcing the **Columnar Format** box will output your results in a simple to export columnar format in the log file.

When you have made all of your selections, click on proceed and the program will perform all measurements on all images a write the results to your log file.

9. Options

The **Options** menu contains a variety of commands that are useful in setting up or optimizing your display for the current task at hand.

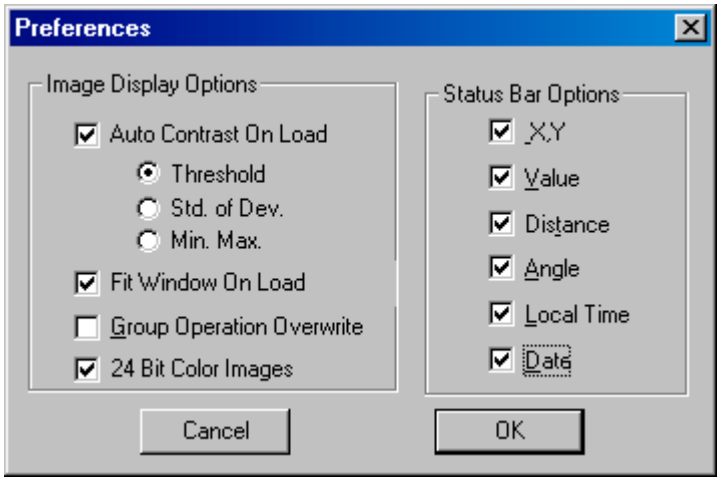
Night Vision

The **Night Vision** command changes all of the standard system colors to shades of red to help maintain your eyes adaptation to the dark. This is useful if you are using the program during actual observing session in the observatory or in the field. After selecting this option you should also lower the brightness on your monitor.

The status of the night vision option is saved from session to session, remember to turn it off when you are using the program in normal lighting.

Preferences

Under **Preferences** you can configure the status bar and set up key option that control the behavior of the program. When selected, the following dialog appears:



The status bar appearance is controlled by the check boxes on the right. On the left are the image handling options.

If you check **Auto Contrast On Load,** the program will automatically prescale images with the indicated method when a new image is loaded. Enabling this option smooths operation of the program considerably. Only when working with merging RGB images or when special displays are required is it recommended to diable this option.

If you check the **Fit Window On Load** option, images are sized to exactly file your display area when loaded. Enabling this option assures you will see all your image on load regardless of your screen size. To see full detail you may still need to zoom in or out with from the main menu.

If you check **24 Bit Color Images**, the program will assume you are running a 16 to 32 bit color card on your computer and will process all color images as 24 bit color. This will greatly increase the speed and ease of dealing with color images. If you need to output 8 bit compressed palette images for rapid internet download, or if your system has only and 8 bit color display, disable this option.

Grayscale Palette and Standard Palette

The **Grayscale Palette** and **Standard Palette** commands are used together to optimize your systems' ability to display gray scale images. If you are running in a standard VGA display mode, these commands will be enabled. Since these commands are not required in other display modes, they will appear disabled.

The standard VGA mode allows only 16 simultaneous colors, with this limitation in mind, Windows requires that these colors be set to the standards 'pure' colors, e.g. red, green, blue, magenta, etc., this provides only two gray values plus black and white. To improve you capability of viewing the high resolution B/W images, Epoch 2000 re-programs the hardware registers on the VGA board to display 16 gray values instead of 16 'pure' colors. By selecting the standard 16 color palette in the **Image**, **Palette** menu when the Grayscale Palette is active, you will be able to view the images in 16 shades of gray

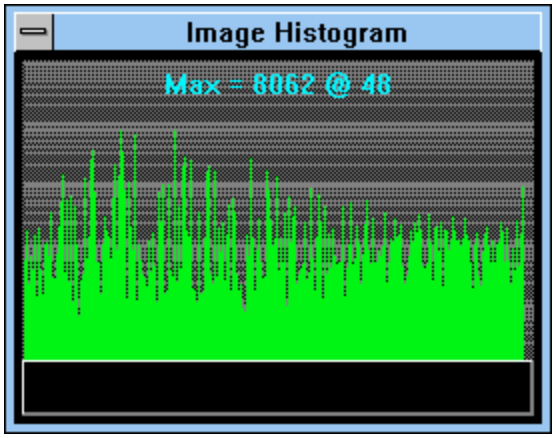
NOTE: The Grayscale Palette function removes all colors from the display leaving only shades of gray. Make sure you restore the regular colors by selecting the Standard Palette before you run other color intensive applications.

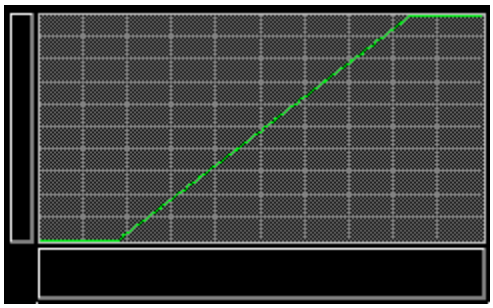
Appendix A

Image Processing Basics

Image processing allows you to modify the appearance of an image by applying various types of filters, scaling options or transformations. The simplest type of processing is **linear scaling.** With linear scaling, one pixel from the source image is multiplied by a scale factor, then an offset term is added. The original pixel value is then replaced with the resulting value. This process is repeated on each pixel in the image.

The **contrast** and **brightness** of the image can be controlled by varying the scale factor (contrast) and the offset value (brightness). You should attempt to set the contrast to a value that allows the full range of the important parts of the image to fall on the sloping section of the transfer curve (see the **Scale Image** function), then set the brightness so that the minimum pixel values appear black or very dark gray. The following histogram and transfer graph illustrates the optimal contrast and brightness settings to give a normal view of the image.





You may need to experiment to find the right settings for any given image. Sometimes it may be necessary to scale different areas of the image using
Another useful image processing technique, **convolution,** allows you to enhance the appearance of an image by 'filtering' the image data by either smoothing (low-pass filter) or sharpening (high-pass filter) or combining parts of both types of filters.

This is accomplished by passing a convolution matrix, or kernel, over the entire image and replacing the center pixel in the resulting matrix with the scaled sum of all of the other values. For example, if you wanted to average each pixel with its adjacent neighbors the following kernel could be used.

1 1 1
1 **1** 1
1 1 1

Each pixel, including the center one, would be multiplied by 1, then the sum of each of these terms is calculated. The result is then divided by the sum of each of the kernel values, in this case 9. Finally, the

center pixel value is replaced with the new result. This process is then repeated for every pixel in the image.
There are many different kernels that you can create that give various results. Meade Autostar IP provides several basic kernels that provide the most common functions, but feel free to experiment. There are a number of image processing books available that will describe other types of kernels.

Bibliography

William K. Pratt, *Digital Image Processing*, second edition, John Wiley & Sons, Inc., New York, 1991

Glossary

absolute magnitude - the apparent magnitude an object would have if it were moved to a distance of 10 parsecs.

angular diameter - the apparent diameter of an object expressed in angular measure i.e., deg, min, sec.

aperture - the diameter of the objective lens or primary mirror of a telescope.

apparent magnitude - the observed brightness of an object without any correction for distance.

astrometry - the branch of astronomy concerned with the precise measurement of positions and motions of celestial objects.

coma - an optical defect that affects only image details away from the center of the field of view causing stars to appear flared, like tiny comets pointing inward from the edge of the field.

focal length - the distance from the lens or mirror to the focal point.

focus - the oint in an optical system where all the image components are brought together.